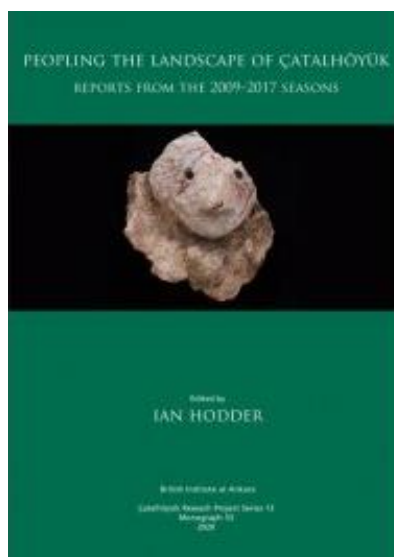


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4. Woodland vegetation, fuelwood and timber use at Çatalhöyük: the anthracological remains from the 1996 to 2017 excavations

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Aims and scope

To date, the anthracological assemblage of Çatalhöyük East represents one of the largest and most intensively studied prehistoric wood charcoal assemblages in Southwest Asia. As indicated in previous publications, the foremost condition that has enabled this intensity and depth of analysis is the exceptional (by comparison to other prehistoric sites in the Eastern Mediterranean region) preservation of charred wood and non-wood archaeobotanical macro-remains at Çatalhöyük. The principal aim of this chapter is to provide a comprehensive account of the anthracological research carried out at the site to date, incorporating the results obtained from laboratory and field analyses carried out between 2015-2017 to analyses carried out and published previously by Asouti (2001, 2005, 2013) and Kabukcu (2015, 2017, 2018a). The new work reported in this chapter includes analyses of context-related variation in charcoal sample composition and its interpretation in terms of charcoal taphonomy and prehistoric fuel wood selection (both in terms of species and log size), alongside the results of ongoing work on the identification of woodland management practices and tree growth conditions in south-central Anatolia. Finally, new data are also presented on the use of timber in Çatalhöyük East.

Materials and methods

Routine analytical methods (charcoal identification and basic quantitative analysis) follow those described in detail in earlier publications (Asouti 2005, 2013). More recent work has also established protocols for the systematic collection and analysis of dendroanthracological data (Kabukcu 2015, 2017, 2018a-b). Dendroanthracological features recorded at Çatalhöyük are classified in three main groups: (i) features relating to the general condition of unburnt wood (evidence of fungal decay, collapsed fibres/vessels/tracheids, insect/ woodworm boreholes), (ii) signs of physiological stress (narrow growth rings, discontinuous/false rings, traumatic canals/ducts, the formation of scar/callus tissue), and (iii) indicators of log sizes used as fuel and their positioning on the tree as branch, twig and/or stem wood (estimated *inter alia* through the recording of the presence of tyloses, pith and/or bark, alongside qualitative and quantitative estimations of growth ring curvature) (Kabukcu 2018a-b).

Following on from previous anthracological work at the site, sample selection focused on deposits containing accumulations of fuel wood waste debris, including midden and other secondary charcoal deposition contexts (e.g., building infills, “dirty floor” deposits, etc.) which permit determining diachronic patterns of routine fuelwood use (Asouti 2005; Asouti and Austin 2005; Kabukcu 2018b). Contextual variation in fuel wood use was explored via multivariate analyses (Correspondence Analysis, CA) of charcoal sample composition involving both internal and external fire features (e.g., wood charcoal from hearths, ovens, fire spots). Spatial patterning in charcoal sample composition was also explored by applying CA on anthracological data originating from midden, fire feature and “dirty floor” deposits.

Results

1. Midden and midden-like deposits

Previous analyses of fuelwood use in the North and South Areas focused predominantly on North G and H/I and South G, G-H, I, J, K, L, M, O, P, Q, R, S and T (Asouti 2013, Kabukcu 2015, 2017). New results presented in this chapter include midden samples from the previously unreported phase South N and midden units from North G, H and I, plus “dirty floor” deposits from North F (from which no midden deposits were available for analysis). The combined results of previous and new analyses are presented in [Table 4.1](#) and, the form of an anthracological diagram in Figure 4.1.

Charcoal sample composition during the earliest phases of occupation at Çatalhöyük (South G) is dominated by a diverse range of riparian woodland taxa including elm (*Ulmus*), hackberry (*Celtis*), elm/hackberry (Ulmaceae), willow/poplar (Salicaceae) and tamarisk (*Tamarix*). Deciduous oak (*Quercus*) charcoal values represent 3% of the total number of identified fragments in South G; a rapid increase is observed during the final phase of South G and in South H up to a maximum of 53% of charcoal composition (percentage fragment counts) (Fig. 4.1). This abrupt change in *Quercus* values composition was initially detected by Asouti (2005, 2013) and was subsequently verified by further analyses conducted by Kabukcu (2015, 2017). From South G-H onwards, deciduous oak dominates charcoal sample

composition until the end of South P, accounting for ~50% of sample composition. In the transition between South P-Q, *Quercus* values drop from 43% to 27% and continue to decrease gradually through South R, S, T. Juniper (*Juniperus*) charcoal is attested in the Çatalhöyük charcoal stratigraphy from the earliest phases of occupation, albeit in low frequencies (<5% of sample composition). Juniper frequencies increase very gradually to 8% in South N and more markedly to 20% in South O (see [Fig. 4.1](#)). This rapid increase may represent, at least in part, an artefact of the low number of midden samples analysed from South O, in light also of the fact that juniper quantities drop again to 7% in subsequent South P. From South Q, juniper values increase to 34% and reach their peak in South S (67%), followed by a small drop to 52% in South T.

The sequence from the North Area mirrors to a certain degree the trends summarised above for the South Area. Similar to the earliest phases excavated in the South area, North F “dirty floor” deposits reflect a high degree of reliance on riparian taxa (*Ulmaceae*, *Ulmus*, and *Celtis*). However, there is a considerable proportion of deciduous oak charcoal during this phase, which is only marginally lower than the frequencies of oak charcoal obtained from South K and L midden samples. At the same time, the proportions of riparian taxa in North F are higher compared to post-South G phases in the South Area. In North H, I there is a pronounced increase in juniper values (from 2.87% in North F through to 10% in North G, 28.6% in North H and 41.38% in North I. This pattern largely mirrors the upward trend in juniper charcoal values and the concomitant reduction in oak charcoal frequencies observed in South P - Q/R ([Fig. 4.1](#)). Furthermore, a gradual increase in almond (*Amygdalus*) and terebinth (*Pistacia*) charcoal values is observed during the later phases of Neolithic occupation (i.e., North I; South R, S and T) in both the North and the South areas.

In order to explore further diachronic trends in charcoal sample composition and context-related variation across the North and South areas, a Correspondence Analysis (CA) was carried out on the sample-by-sample charcoal taxon counts of 128 midden and midden-like contexts derived from all sampled phases of occupation ([Fig 4.2](#)). The CA biplot demonstrates the affiliation of the North F “dirty floors” with the South K, L and M midden samples (high proportion of oak and similar proportions of riparian taxa). It also shows that the North G and South N, O and P middens are similarly positioned with regard to the proportions of *Celtis*, *Ulmus* and *Quercus*. North I and H are clustering together with South R, S and T reflecting similar proportions of *Juniperus*, *Tamarix*, *Fraxinus*, *Amygdalus* and *Pistacia* in their samples. Finally, it is possible to observe a greater variability in sample composition within phases South Q, R, S, T and North I, H, whereby some samples have lower proportions of juniper and others higher proportions of *Fraxinus*, *Amygdalus* and, to a certain extent, *Tamarix* and *Pistacia*. Such variability is not observed within earlier South Area phases (e.g., South K, L, N) or in the North G and F samples.

2. Primary fuel waste deposits (hearths/ovens and fire spots)

Previous anthracological analyses at Çatalhöyük have provided accumulating data on the taxonomic composition of samples derived from primary fuel waste deposits (Kabukcu 2015;

see also Asouti 2013). For the purpose of the present study we performed a multivariate analysis of all the available samples in order to (i) investigate variation in charcoal sample composition between different types of fire features, and (ii) explore any latent diachronic and/or spatial patterning in taxon representation. CA was applied on the sample-by-sample charcoal taxon counts from 56 internal (hearths/ovens) and external (fire spots) fire features across multiple phases of occupation, which preserved at least 25 identified charcoal fragments ([Fig 4.3](#)). The CA biplot demonstrates that the majority of internal fire features from all phases in the North and South areas cluster around deciduous oak (*Quercus*). This pattern holds, regardless of diachronic patterns in taxon representation observed in midden and midden-like samples. For example, 2 internal fire features from South Q contain predominantly *Quercus*, while juniper predominates the 6 midden samples studied from this phase. By contrast, as the CA biplot demonstrates, external fire features from all phases of occupation contain a much greater diversity of taxa including combinations of oak and/or juniper and riparian taxa. In some cases, sample composition replicates the patterns identified in midden deposits from the same phase (e.g., South G external fire features contain high quantities of Ulmaceae just like the midden samples from the same phase). On the other hands, while South P middens are overall dominated by *Quercus*, external and internal fire features in South P are very variable in their composition: some external fire features from South P contain more riparian taxa or *Juniperus* (see [Fig 4.3](#), upper right-hand corner of the CA biplot) while other external and internal South P fire features are dominated by deciduous oak (see [Fig 4.3](#), lower right-hand corner of the CA biplot).

The variability observed in the charcoal sample composition between internal and external fire features warranted further exploration of context-related variation in taxon representation. ‘Dirty floor’ deposits at Çatalhöyük represent accumulation of waste inside buildings at variable lengths of time. This accumulation, sometimes at high densities, occurs despite the repeated cleaning of domestic floors and the discard of waste in middens. We therefore decided to investigate further context-related variation in taxon composition in phase North G, which comprises 31 charcoal samples from fire features, midden deposits and “dirty floor” contexts. The resulting CA biplot ([Fig 4.4](#)) demonstrates that “dirty floor” samples closely follow the sample composition of internal fire features (in this case both containing predominantly deciduous oak charcoal). In addition, while North G midden deposits are also dominated by oak, at the same time they contain a greater diversity of charcoal taxa including *Juniperus*, *Amygdalus*, *Fraxinus*, *Pistacia*, Ulmaceae, etc. (see [Fig 4.4](#), upper right-hand side of the plot). Interestingly, as identified in the CA carried out on fire feature samples ([Fig. 4.3](#)) there is also variability in the composition of external fire feature charcoal samples, with some being similar in composition to internal fire features and others resembling more midden samples.

3. Results of dendroanthracological analyses

Qualitative estimations of log sizes were applied to 3,762 individual charcoal fragments separating them into 3 main size classes: CD1=weakly curved rings, corresponding to larger diameter wood; CD2=moderately curved rings, corresponding to smaller diameter trunk

wood; and CD3=highly curved rings, corresponding to twigs and small branches (see Kabukcu 2018a). The results revealed a greater predominance of medium-size logs (CD2), followed by small diameter wood (CD3) and much lower frequencies of large diameter logs (CD 1) (see also [Table 4.2](#)). These proportions are replicated across the anthracological assemblage including both primary fuel waste deposits as well as midden and midden-like secondary deposits. Previous work has highlighted the lack of significant variability in the distribution of log sizes across all sampled phases of occupation (Kabukcu 2015, 2018a). Instead, log sizes appear to vary in a taxon-specific manner. *Quercus*, *Juniperus*, *Ulmus* and *Fraxinus* and ash are represented predominantly by fragments derived from medium-size logs in both fire features and midden deposits (see [Figures 4.5](#) and [4.6](#)). By contrast, charcoals of fruit/nut bearing taxa such as *Amygdalus*, *Pistacia*, Maloideae (apples, pears and hawthorns) comprise predominantly fragments originating from small diameter wood ([Fig 4.5](#)). It is necessary to note here that *Juniperus*, Ulmaceae, Salicaceae and *Fraxinus* included numerous fragments that were not assigned a CD class due to the overall small size of their charcoal fragments, poor preservation or the specific qualities of their wood anatomy. For example, juniper is characterized by naturally wavy growth ring boundaries often including false and/or discontinuous growth rings, hence ring curvature may be very difficult to ascertain for small *Juniperus* charcoal fragments, while Salicaceae may have indistinct growth ring boundaries, particularly in dead/decayed wood.

Quantitative estimations of log diameter were carried out using the trigonometric method, involving the triangulation of the angle between wood rays and growth ring boundaries (see detailed exposition in Kabukcu 2018a). As this method relies on the clear observation of rays, growth ring boundaries and multiple growth rings, its application on the assemblage was limited to large charcoal fragments (>10mm) of ring-porous taxa characterised by large and clearly visible rays and large earlywood vessels; in the present study these were limited to *Quercus*, *Fraxinus*, *Ulmus* and *Celtis* (150 fragments across all phases in the South Area). Quantitative log diameter estimations yielded similar results to the qualitative growth ring classification (CD classes discussed above) (see [Fig 4.7](#)). Firstly, the majority of measured specimens were identified as derived from medium to small diameter logs (<15cm in minimum diameter). Secondly, the comparison between CD classes and log diameter estimations performed on the same specimen indicated that overall the qualitative technique provides a sufficient blueprint for separating between small (<5cm min. diameter), medium (~8-6cm min. diameter) and large (>10cm min. diameter) log sizes across the measured specimens ([Fig 4.8](#)).

Further indicators of log size selection and use has derived from recording the frequency of occurrence of pith, bark and tyloses. In some taxa (e.g., *Quercus*, *Ulmus*, *Celtis*, *Fraxinus*) the presence of tyloses in >90% of the observable early wood vessels in consecutive growth rings may indicate derivation from the heartwood of mature stems/trunks. Across the studied dendroanthracological assemblage from Çatalhöyük tyloses were commonly observed (>60% of all analysed fragments; see [Table 4.2](#)). Tyloses were most commonly observed in oak, alongside a higher incidence of CD2 and CD1 diameter size classes. While there is a considerable proportion of CD3 fragments (totalling 958 observations; see [Table 4.2](#)) observations of pith and/or bark were considerably low by comparison. Thus, the high

numbers of small and medium diameter specimens in the assemblage are likely to have derived from both twigs, branches and small diameter heartwood. The under-representation of the sapwood regions (i.e., larger diameter log portions) could reflect log burning without prior splitting, thus leading to the complete combustion of the larger diameter log portions.

With regard to the general condition of fuelwood used, there is ample evidence for the use of deadwood and/or wood stored for sufficient periods to provide time for the development of fungal decay: nearly half of all the examined specimens displayed signs of fungal hyphae (see [Table 4.2](#)). Less frequently, more advanced signs of decay such as insect boreholes and collapsed vessels/tracheids were also recorded.

Traumatic resin canals or gum ducts were relatively frequent (~20% across the studied assemblage). In some cases, other forms of growth irregularities were also recorded under this category, such as tyloses formed in isolated regions within the woody tissue (see [Figure 4.9](#)), which could suggest the reaction of riparian taxa to sudden fluctuations in water levels. Narrow (<0.2mm) and false growth rings were also observed in similar frequencies as traumatic growth (~20%). Both types of features relate to physiological stress and were particularly common among *Juniperus* specimens. Narrow and false growth rings have also been recorded in *Quercus*, *Ulmus*, *Celtis* and *Fraxinus* (see [Fig 4.9](#)). Stress indicators are not limited to large diameter wood; they have been observed frequently in smaller diameter specimens, possibly indicating prolonged periods of stress resulting in dwarf growth forms.

In tandem with quantitative log diameter calculations, growth ring width measurements were also carried out, recording annual growth-ring width sequentially. The aim was to explore in a more systematic manner tree growth conditions and characterise possible anthropogenic impacts on woodland habitats. In temperate environments, annual growth increments are distinct and are largely influenced by climatic conditions, tree physiology and other external factors (e.g., human and animal impacts on individual trees). Thus, the study of annual growth-ring width provides a method for understanding woodland growth conditions and habitats. As the tree ages annual increment in growth-ring width (observed along the radius of the tree) narrows with increasing trunk diameter. This situation necessitates plotting ring width against log diameter in order to produce realistic reconstructions of changing tree growth rates. For this reason, ring width measurements were carried out only on specimens on which trigonometric diameter calculations were performed. In order to investigate differences in rates of tree growth between riparian and semi-arid woodlands, average ring width measurements for each specimen were plotted against respective diameter estimations (see [Fig 4.7](#)). The plot of average ring width shows that there is a great degree of variability in rates of growth in smaller diameter size classes (particularly in stems <10cm). A significant number of specimens in this group are characterised by markedly reduced growth (<0.5mm). At the same time, a large number of small diameter specimens display average rates of growth above the median (between 1-2mm). A further group within the <10cm diameter category display average ring width of >3mm. Such variability in average growth rates does not appear to relate to the micro-ecologies of different ecotones (e.g., riparian vs. semi-arid). All three groups include specimens of both riparian and semi-arid taxa. Furthermore, the larger diameter specimens also demonstrate stable and reduced annual

growth rates (0.8-1.5mm). As expected, the effect of increasing trunk diameter and age result in relatively narrower growth ring width.

Additionally, we investigated variation in growth ring width observed within the same specimen:

$$\text{delta} = \text{Max (ring width)} - \text{Min (ring width)}$$

The aim was to capture abrupt shifts in annual growth rates (see [Fig 4.7](#)). Studies on present-day managed woodlands indicate that cyclical cutting practices impact on wood anatomy in two main ways: abrupt increase (2-3 fold increase) or a significant decrease in annual growth which are then sustained for a number of years. For example, coppice woodlands comprise species which regenerate vegetatively and rely on the rapid responses of trees to the cutting of their trunks at the base by releasing shoots in the following growth season. After a cycle of cutting, the new shoots growing from the cut trees and the remaining trees experience a period of improved growth conditions characterised by an abrupt increase in ring width (referred to as growth release period) (Schweingruber et al. 1990, Corcuera et al. 2006, Altman et al. 2013, Schweingruber 2007). Furthermore, shoots growing from coppice stools tend to have wider growth rings compared to seedlings and saplings growing from seed. This improved period of growth is sustained for 5-10 years, followed by a period of reduced growth rates, as competition for light and nutrients intensifies brought about by increased canopy density (referred to as growth suppression period) (Schweingruber et al. 1990, Rozas 2004, Bleicher 2014). On the other hand, silvicultural practices such as pollarding, crown lopping and leafy fodder harvesting result in sustained periods of abrupt growth reduction (growth suppression). In pollarded trees, wide-scale loss of foliage leads to significant reduction of annual growth, with recovery to ‘normal’ rates occurring as the crown regenerates by releasing shoots from the trunk. Similarly, defoliation (e.g., by herbivore browsing) can also result in growth reduction (narrow growth rings, often accompanied by false growth rings) ([Fig. 4.9](#); see also Thiébaud 2006, Schweingruber 2007: 139).

In the Çatalhöyük dendroanthracological assemblage, observations on both average and delta ring width values display considerable variability. A significant number of specimens display very minor shifts in annual growth; these correspond to the group with low average ring-width values as well and may represent saplings growing under sustained competition (e.g., closed canopy, repeated cutting and/or browsing). This group includes both riparian and semi-arid taxa, thus re-affirming that predominant woodland growth patterns are not controlled primarily by the micro-ecologies of the various woodland catchments. Furthermore, taxa displaying higher variability in growth rates (i.e., greater delta ring width values) are in the smaller diameter group, while more stable growth rates are observed in the larger diameter classes. We argue that this situation reflects the occurrence of three distinct groups of growth forms in the Çatalhöyük assemblage: twigs/branches, sapling stems and regenerating shoot stems, which are observed in all the taxa from which ring-width measurements were obtained. At the same time, there is ample evidence for severe growth suppression in several specimens ([Fig 4.9](#)) derived from both riparian and semi-arid woodland taxa. These are likely to represent the impacts of repeated episodes of defoliation (e.g., from leafy fodder collection, animal browsing, etc.)

4. Evidence for timber use

Several burnt buildings have yielded *in situ* preserved carbonised timbers and other structural/construction wood remains. In addition to the analyses of timber remains previously reported by Asouti (2013), we report here new evidence obtained from the 2012-2017 excavation seasons (see [Table 4.3](#)). Burnt buildings are found in South O and North G, F phases; for this reason, it is not possible to provide evidence of diachronic trends in timber selection and use. Two structures in the South area, Buildings 80 and 97 (South O) contained charred timber elements. Juniper and elm specimens retrieved from Building 97 derived from an *in situ* preserved partition wall. Partition wall timber elements were not recovered at Building 80, however the collapse fill of this building contained significant quantities of juniper timber elements; some of which may belong to the collapsed roof structure. 4 *in situ* timber elements preserved inside the pillars were also recovered in Building 80 derived from oak (20082), juniper (18961, 18959) and elm (18960). The excavation of (20082) inside pillar F.3428, established that the oak timber sat at the base of the pillar, was ~30cm in width, and had been sourced from a halved trunk with a maximum height of ~45cm. The remainder of the pillar above (20082) was filled with coarse and heterogenous construction/packing material. This building also provided the *in situ* charred remains of an oak ladder (18963), produced from a halved oak trunk of ~20cm in preserved width.

3 burnt buildings in the North Area, Buildings 52, 77 and 131, also yielded carbonised timber remains. In all 3 buildings several small posts (<10cm in diameter) and various timber elements from roof collapse were identified as elm, willow/poplar and oak. While roof collapse remains of juniper timbers were recovered in Building 77, juniper was absent from Buildings 52 and 131. The timbers used in plastered pillars in Building 77 and 131 comprised elm and oak. The low height of the timber used was observed clearly in the east wall pillar of Building 131, where an elm timber (23018) of ~42cm width was inserted into the base of the pillar; the preserved height of (23018) did not exceed 30cm. Similar to the pillar features excavated in Building 80, this pillar was filled with heterogenous packing materials. The same method of pillar construction is also attested in buildings from which there is no evidence of burning. For example, the mineralised remains and impression of a timber (21804) were discovered in the eastern wall pillar of Building 43 in the South area. Here again, the timber appears to have been inserted at the base of the pillar, and the space above it filled with coarse construction material; the entire pillar was subsequently plastered.

A series of *in situ* carbonised timber remains discovered in the side room (space 504) of Building 131 including a large oak timber (~20-25cm in diameter) do not appear to be related to specific features. 3 further small posts were also recovered in this space (all identified as elm, ~12-15cm in diameter).

The well preserved *in situ* timbers belonging to the partition walls of Building 77 and 131 suggest the use of off-cuts, reduction waste from post and pillar preparation in these construction elements. In Building 77, as previously reported by Asouti (2013), these comprised juniper and oak stems, split along the tangential plane of the wood. Similarly, in Building 131, partition wall timbers were derived from elm (also used in the pillars of the same building) and were split tangentially in order to obtain uniform thickness along the base

of the partition wall (see also Table 4.3). Further research and analyses on timber preparation and use practices are currently ongoing and may provide further insights into the reduction methods and curation of timber elements used in construction (Asouti in prep).

Sub-floor burials uncovered in Buildings 52 and 131 also yielded in situ remains of carbonised wooden artefacts placed in the fill of the burial. Burial F.7956 (Building 131) contained the preserved remains of a small wooden bowl made from maple (*Acer*) wood (Fig X.9). 2 more objects (possibly bowls) made from oak and ash wood were recovered in the fill of F.7962. A small almond branch (with 7 visible growth rings) appears to have also been included in the fill (Fig 4.9). The fill of F.7127 (30503) in Building 52 also contained a small wooden bowl, made from maple wood in a similar manner to the item found in the Building 131 burial.

Discussion

1. Regional woodland vegetation

Previously published reconstructions of early to mid Holocene woodland vegetation in the Konya plain of south-central Anatolia based on charcoal macrofossils, species distribution modelling and modern vegetation surveys from this region, have all suggested that open oak and juniper woodlands were widespread on to the low to mid elevation limestone and volcanic slopes surrounding the plain, including well-drained red-brown soils, clayey loams, limestone terraces and colluvia (Asouti and Kabukcu 2014, Kabukcu 2017, Collins et al. 2018). Riparian woodlands, including willow, poplar, elm and ash were widespread along seasonal and permanent watercourses, on the alluvial floodplains and fans accumulated on the Konya plain from inflowing rivers and streams and on the edges of seasonally flooded wetlands and marshes (Collins et al. 2018). A range of other shrubs and herbs, frequently observed in the anthracological assemblages from the Konya plain such as *Artemisia*, *Chenopodiaceae*, *Capparis*, *Labiatae* and *Fabaceae* shrubs probably occupied the edges of wetlands and the marl steppe on the more arid interiors of the plain (Asouti and Kabukcu 2014). The available ecological literature and species distribution modelling also suggests indicates that important fruit and nut-bearing taxa such as almonds, terebinths, hawthorns and wild pears likely formed elements of semi-arid and steppe open grasslands on the lower Taurus foothill zone, as well as on the steppe-alluvium ecotones (Asouti and Kabukcu 2014, Kabukcu 2017, Collins et al. 2018).

The anthracological sequence from Çatalhöyük provides valuable insights into the diachronic development of the regional woodland vegetation and prehistoric landscape impacts. The earliest phases of occupation (South G), with their distinctive focus on riparian charcoal taxa, provide close parallels to the anthracological assemblage retrieved from the neighbouring 9th-8th millennia cal BC site of Boncuklu (Kabukcu 2017). However, the available anthracological assemblages also reveal sharp differences in the local micro-ecologies during the early Holocene. The anthracological assemblage from Boncuklu that occupied a distinctive marsh setting, including permanently submerged areas, is overwhelmingly dominated by *Salicaceae*. By contrast, the assemblage retrieved from 9th millennium

Pınarbaşı A situated on the volcanic Karadağ foothills and steppe-wetland ecotone was dominated by *Amygdalus*, and that of 8th millennium Can Hasan III on the Selerecki fan by *Amygdalus*, *Pistacia* and *Ulmaceae* (Kabukcu 2017). The first two millennia of the Holocene are reflected in the regional pollen records (Eski Acıgöl in Cappadocia) as a period characterised by low arboreal vegetation density (Roberts et al. 2001) although the regional pollen spectra fail to register insect-pollinated taxa (Rosaceae, Maloideae) and poor/sporadic pollen producers (Salicaceae, *Fraxinus*, *Pistacia*, *Juniperus*, *Celtis*) are systematically under-represented, or altogether absent, in the regional pollen archives. Interestingly, the onset of the increasing values for deciduous oak pollen (dated at ~9000 cal. BP in the Eski Acıgöl core) appears as largely synchronous with the sharp increase in the oak charcoal frequencies in South G-H (Fig. 4.1). Arboreal pollen and oak pollen values continue increasing in the Eski Acıgöl sequence until ~6000 cal. BP, i.e. post-dating the late Neolithic occupation of Çatalhöyük East. However, despite this continuous increase of oak pollen values, the Çatalhöyük anthracological sequence indicates that after South P, deciduous oak was substituted by juniper as the dominant charcoal taxon. Set against the regional pollen data, the increasing frequencies of juniper charcoal through the later part of the Çatalhöyük anthracological sequence (South Q to T and North H/I) thus appear to reflect a genuine local switch in wood preferences rather than oak regression due to deforestation or climate change and its replacement by juniper (Asouti and Kabukcu 2014, Kabukcu 2017).

2. Woodland growth conditions and anthropogenic impacts on woodland vegetation

Riparian woodlands in the environs of Çatalhöyük included a mixture of fast- and slow-growing taxa. While there are clear diachronic fluctuations in the proportions of fuelwood use from riparian woodlands, riparian taxa are nevertheless present in all phases of occupation. The continuous presence of shade-tolerant (*Ulmus*, *Fraxinus*) and shade-intolerant taxa (Salicaceae, *Celtis*) suggest a relatively stable and productive riparian woodland catchment, growing mostly if not exclusively (at least for the Salicaceae) on well-drained soils. It also appears likely that some *Ulmus* trees were protected, as the limited dataset from timbers at the site point to the use of large elm stems (e.g., 40-50cm in diameter) especially in the middle Neolithic phases of the site.

Examination of log sizes used throughout the phases of occupation highlighted the prominent use of small and medium sized logs as fuel (<15cm in minimum diameter) with evidence for the harvesting and use of all parts of the tree (twigs, branches and stem wood). The evidence from diameter estimations suggests the routine use of smaller logs as fuel (<15 cm) compared to evidence from timbers (~40-50cm occasionally up to 80cm in diameter; cf. Asouti 2013). Growth ring width data collected for ring porous species such as *Quercus*, *Ulmus*, *Celtis* and *Fraxinus* suggest the presence of cyclical shifts in growth rates commonly associated with managed woodlands (i.e., growth release and suppression that might indicate the occurrence of both pollarding and coppicing/pruning practices). The distribution of slow growth periods followed by years of significantly improved conditions has also been observed within single *Quercus*, *Ulmus* and *Celtis* charcoal specimens (Kabukcu 2018a). This suggests a general tendency in these taxa to experience several years of limited growth (or slower growth rates)

followed by years of accelerated growth rate, likely arising from brief periods of reduced competition. As suggested above, this pattern is compatible with observations of growth patterns in coppiced woodlands. Alternatively, it could indicate the response of individual trees to episodes of thinning of the understorey vegetation in denser woodland stands. Selective thinning of the understorey and the protection of individual trees might also have enhanced the development of larger diameter stems that could have been preferred (hence intentionally managed) for use as timber. As both *Ulmus* (shade-tolerant) and *Quercus* (shade-intolerant) specimens display the same pattern, it is highly likely that its underlying causes reflect anthropogenic impacts rather than episodes of natural disturbance. The presence of scar/callus tissue and radial overgrowth on specimens from the same taxa provide additional confirmation for impacts on wood anatomy resulting from intentional cutting, pruning and/or debarking. Additional impacts associated with severe defoliation (i.e., successive very narrow and discontinuous (false) growth rings) suggest that both semi-arid and riparian woodlands were potentially affected by herbivore browsing, although such eco-anatomical features were not common in the dendroanthracological assemblage (being present in ~15% of the analysed specimens; see [Table 4.2](#)).

A particularly interesting aspect of the dendroanthracological assemblage is the high frequency of narrow and/or false growth rings observed in *Juniperus* charcoals. This taxon displayed markedly slow growth throughout the sampled sequence, an observation which was previously reported by other researchers working on the Çatalhöyük charcoal assemblage (cf. Newton 1996, Asouti 2013). In addition, the frequent signs of trauma observed in juniper specimens ([Fig 4.9](#)), point to repeated disturbance of juniper growth caused by environmental factors such as frost, insect or mechanical damage and moisture deficiency. In the ecological literature it is reported that the main driver of continuously narrow growth rings (indicating slow growth rates) in junipers are dry and hot conditions during the spring and early summer (Sass-Klaassen et al. 2008; Liang et al. 2011; Esper et al. 2014). This is due to the fact that most of the radial growth in junipers consists of early wood tracheids formed in spring and early summer. Thus, consistently dry and hot growth seasons will result in very slow growth rates, including higher frequency of false rings.

3. Fuel wood/timber use and context-related variation

Semi-arid oak and juniper woodlands would have been available at some distance from Çatalhöyük (~10-15km) (Collins et al. 2018). The diachronic trends in the proportions of *Quercus*, *Juniperus* and riparian taxa (the most common components of the Çatalhöyük anthracological assemblage) indicate an increasing reliance on the use of more distant woodland habitats through time, first of oak-dominated vegetation and in later periods of juniper woodlands. This trend however does not appear to have been caused by local deforestation and the depletion of riparian vegetation and (later) oak woodlands. Considering the local and regional anthracological data in the context of the available pollen and climatic evidence, a more parsimonious explanation for the diachronic variations observed in the Çatalhöyük anthracological assemblage is that they reflect a complex fuel and timber economy with varying pyro-technological needs and cultural preferences, which resulted in

the selective use and management of both proximate and more distant woodland habitats. A determining factor in species selection may have also been the responses of individual taxa to cutting and thinning (discussed in the previous section). Thus, taxa, which were culturally valued as timber and harvested regularly for construction wood (i.e., *Quercus*, *Juniperus*, *Ulmus*) also provided a storable supply of dense and slow burning firewood through crown removal and timber preparation waste. In addition, riparian taxa (*Salicaceae*, *Fraxinus*, *Ulmus*, *Celtis*) that responded well to regular cutting by vegetative regeneration and vigorous regrowth, may have been preferred as a staple fuel wood source, without resulting in the depletion of local riparian habitats proximate to the site. *Quercus* and *Ulmus* could also have provided a ready supply of high-quality leafy fodder for domestic animals penned during winter months. Multivariate analyses of midden and midden-like samples also highlighted a greater degree of variability in the species composition of samples dating to the later phases of Neolithic occupation, particularly in relation to the proportions of taxa from semi-arid (*Juniperus*) and riparian (*Fraxinus*) woodland catchments. This may reflect the use of increasingly diverse landscape units and associated woodland catchments (evidenced inter alia in Carbon and Nitrogen increasing variability in isotope ratios of caprines during the later phases of occupation, signalling to the possibility that either herds were divided and ranged in different locations or that collectively encountered more diverse environments through their lifespan, Pearson 2013) and/or heightened seasonal variations in fuel use and discard practices.

Across all phases of occupation, the study of charcoals from internal and external fire features points to a distinctive preference for *Quercus* wood as the fuel of choice for domestic fireplaces, whereas external fire spots are taxonomically more diverse including evidence for the use of lower quality fuels (such as dung, which is largely avoided in indoor contexts) (Bogaard et al. this volume, 2013, Filipović 2014). Whether these identified trends in fuel use relate to pyro-technological requirements or seasonal fluctuations in the availability of fuel resources could be investigated further through future multi-disciplinary research. The most important quality of fuel wood regarding ‘clean’ burning is moisture content. Wood that has not been properly seasoned prior to burning, or is burned in a green state (i.e., shortly after cutting) will invariably produce high amounts of smoke and be a poor heat emitter. Thus, it is not surprising that the use of dry deadwood and seasoned wood is well evidenced across the sampled sequence. In addition to the evidence from Çatalhöyük, other Neolithic sites in the Konya plain (Pınarbaşı, Boncuklu and Can Hasan III) also contain ample evidence for the use of dry deadwood as fuel (Kabukcu 2017). This pattern points to high levels of deadwood productivity in the Konya plain semi-arid and riparian woodlands, which was probably enhanced through seasonal woodcutting allowing logs to dry off-site, thus further facilitating the collection and transportation back to the settlement of lighter fuel wood loads. Such practices may explain the lack of evidence to date for on-site fuel wood storage, although stored dry wood could have also been located on rooftops, open areas (courtyards, middens) and on the settlement edges.

Conclusions

The analysis of the anthracological assemblage from Çatalhöyük has provided important insights into Neolithic woodland composition, ecology and use during the early-mid Holocene in prehistoric south-central Anatolia. This very well-preserved assemblage has provided the earliest documented case for prehistoric woodland management practices in the Eastern Mediterranean region.

This chapter represents the culmination of 20 years of research on the anthracology of prehistoric occupations in the Konya plain of south-central Anatolia, supported by extensive woodland vegetation survey and documentation that supplemented routine archaeological fieldwork and laboratory analyses. Çatalhöyük formed the centrepiece of this research due to the unprecedented combination of excellent preservation conditions coupled with long-term multidisciplinary contextual analyses, involving archaeobiological, environmental, architectural and material culture studies. It thus provided the springboard for testing and developing novel methodologies in the field of anthracology and their first systematic application outside the geographical limits of the western European temperate environments. Importantly, for the Eastern Mediterranean and Southwest Asia regions, our research on prehistoric habitations in south-central Anatolia has firmly established anthracology as an invaluable source of high-resolution palaeoecological archives on the regional vegetation histories and the evolution of anthropogenic landscapes. Future research at Çatalhöyük and other prehistoric sites in the Konya plain of south-central Anatolia will undoubtedly continue to provide novel insights and avenues for methodological developments (especially in fields such as wood ecoanatomy, the analysis of artefactual wood and stable isotope applications).

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Table 4.1 Per phase summary of fragment counts (C) and percentage fragment counts (C%) from midden and midden-like contexts at Çatalhöyük East, incorporating datasets produced by Asouti (2003, 2005, 2013) and Kabukcu (2015, 2017); N: number of analysed samples.

Phase	South G (N=18)		South G-H (N=13)		South I (N=6)		South J (N=2)		South K (N=9)		South L (N=11)		South M (N=4)		South N (N=7)		South O (N=2)	
	C	% C	C	% C	C	% C	C	% C	C	% C	C	% C	C	% C	C	% C	C	% C
<i>Juniperus</i>	9	0.80	7	0.56	1	0.16	2	0.94	23	2.51	28	2.40	20	5.00	27	7.96	36	20.81
<i>Quercus</i>	31	2.75	651	52.46	384	61.44	130	61.03	371	40.46	636	54.55	253	63.25	160	47.20	78	45.09
<i>Amygdalus</i>	21	1.87	4	0.32	1	0.16	1	0.47	7	0.76	8	0.69	1	0.25	10	2.95	10	5.78
<i>Pistacia</i>	39	3.46	19	1.53	1	0.16	1	0.47	26	2.84	19	1.63	14	3.50	9	2.65	2	1.16
<i>Prunus</i>	1	0.09	2	0.16						0.00	8	0.69	2	0.50	1	0.29		
Maloideae	16	1.42	19	1.53	1	0.16	7	3.29	68	7.42	19	1.63	4	1.00			1	0.58
Anacardiaceae			1	0.08					1	0.11	1	0.09					4	2.31
<i>Rhamnus</i>			3	0.24														
Ulmaceae	473	42.01	119	9.59	88	14.08	26	12.21	110	12.00	61	5.23	5	1.25	56	16.52	7	4.05
<i>Ulmus</i>	86	7.64	28	2.26	7	1.12	2	0.94	37	4.03	70	6.00	38	9.50	2	0.59	16	9.25
<i>Celtis</i>	132	11.72	126	10.15	12	1.92	3	1.41	67	7.31	69	5.92	11	2.75	9	2.65	1	0.58
Salicaceae	281	24.96	226	18.21	126	20.16	28	13.15	127	13.85	146	12.52	31	7.75	47	13.86	15	8.67
<i>Fraxinus</i>			1	0.08	1	0.16	12	5.63	7	0.76	24	2.06	2	0.50	6	1.77		
<i>Acer</i>									2	0.22	5	0.43	2	0.50				
Chenopodiaceae	7	0.62	9	0.73	2	0.32			10	1.09	18	1.54	3	0.75	5	1.47		
<i>Artemisia</i>	14	1.24	15	1.21					11	1.20	8	0.69	2	0.50	5	1.47		
Leguminoaseae	1	0.09	8	0.64					38	4.14	31	2.66	2	0.50			2	1.16
<i>Capparis</i>			1	0.08					4	0.44	1	0.09	1	0.25				
<i>Tamarix</i>	3	0.27							1	0.11	1	0.09	3	0.75	2	0.59	1	0.58
Caprifoliaceae	1	0.09											1	0.25				
<i>Alnus</i>											1	0.09	2	0.50				
<i>Vitex</i>	2	0.18	2	0.16							4	0.34	1	0.25				
Platanus											1	0.09						
<i>Ficus carica</i>											1	0.09						
<i>Ephedra</i>	1	0.09																
Labiataeae	5	0.44			1	0.16	1	0.47	6	0.65	5	0.43	1	0.25				
Rosaceae	3	0.27							1	0.11	1	0.09	1	0.25				
Total Identified	1126		1241		625		213		917		1166		400		339		173	

Table 4.1 *Continued from overleaf*

Phase	South P (N=7)		South Q (N=6)		South R (N=6)		South S (N=7)		South T (N=5)		North F (N=7)		North G (N=12)		North H (N=2)		North I (N=9)	
	C	% C	C	% C	C	% C	C	% C	C	% C	C	% C	C	% C	C	% C	C	% C
<i>Juniperus</i>	42	7.14	104	34.90	116	41.43	294	67.28	91	52.91	14	2.87	116	10.14	75	28.63	324	41.38
<i>Quercus</i>	270	45.91	83	27.85	53	18.93	48	10.98	28	16.28	147	30.18	540	47.20	102	38.93	239	30.52
<i>Amygdalus</i>	8	1.36	11	3.69	23	8.21	35	8.01	12	6.98	4	0.82	20	1.75	5	1.91	36	4.60
<i>Pistacia</i>	6	1.02	10	3.36	7	2.5	15	3.43	13	7.56	11	2.26	31	2.71	5	1.91	21	2.68
<i>Prunus</i>	2	0.34									3	0.62	1	0.09				
Maloideae	6	1.02									26	5.34	2	0.17				
Anacardiaceae																		
<i>Rhamnus</i>											1	0.21					2	0.26
Ulmaceae	96	16.32	27	9.06	25	8.93	7	1.60	13	7.56	143	29.36	184	16.08	22	8.40	74	9.45
<i>Ulmus</i>	22	3.74	11	3.69	4	1.43	4	0.92	1	0.58	15	3.08	79	6.91	11	4.20	31	3.96
<i>Celtis</i>	17	2.89	5	1.68	7	2.5	1	0.23			54	11.09	29	2.53	7	2.67	7	0.89
Salicaceae	102	17.35	21	7.05	3	1.07	2	0.46	5	2.91	56	11.50	69	6.03	10	3.82	23	2.94
<i>Fraxinus</i>	3	0.51	23	7.72	41	14.64	28	6.41	9	5.23			50	4.37	24	9.16	22	2.81
<i>Acer</i>					1	0.36	2	0.46			2	0.41	1	0.09				
Chenopodiaceae											2	0.41	6	0.52				
<i>Artemisia</i>	6	1.02	2	0.67			1	0.23			6	1.23	11	0.96	1	0.38	1	0.13
Leguminosae	1	0.17																
<i>Capparis</i>	2	0.34									1	0.21	2	0.17				
<i>Tamarix</i>	4	0.68	1	0.34									2	0.17			3	0.38
Caprifoliaceae																		
<i>Alnus</i>																		
<i>Vitex</i>																		
<i>Platanus</i>																		
<i>Ficus carica</i>	1	0.17																
<i>Ephedra</i>																		
Labiatae											2	0.41						
Rosaceae																		
Total Identified	588		298		280		437		172		487		1144		262		783	

Table 4.2 Summary of dendro-anthracological observations (numbers of fragments exhibiting individual features) obtained from wood charcoal fragments from midden/midden-like contexts and fire features at Çatalhöyük.

Dendro-anthracological features		Midden contexts		Fire features	
		Count	%	Count	%
Curvature degree (Marguerie and Hunot 2007)	1	137	8.0%	13	2.3%
	2	850	49.4%	319	57.2%
	3	733	42.6%	225	40.4%
	N/A	1048	N/A	437	N/A
Pith		195	7.0%	125	12.6%
Bark		41	1.5%	59	5.9%
Tyloses		1802	65.1%	620	62.4%
Traumatic resin canals/gum ducts		599	21.6%	144	14.5%
Fungal hyphae		1335	48.2%	610	61.4%
Narrow growth rings		424	15.3%	177	17.8%
Radial cracks		145	5.2%	22	2.2%
Collapsed vessels		180	6.5%	37	3.7%
Boreholes		44	1.6%	2	0.2%
Scar/callus tissue		30	1.1%	1	0.1%
Mineral deposits		166	6.0%	75	7.5%
Reaction wood		44	1.6%	9	0.9%
False rings		45	1.6%	10	1.0%
Knots		193	7.0%	60	6.0%
Total number of analysed wood charcoal fragments		2768		994	

Table 4.3 Taxon identifications of timber remains from Buildings 52, 131, 77, 97 and 80.

Building 52 (North Area, North G)

	Unit	Feature	Description
<i>Quercus</i>	17996	2172	Pillar
<i>Ulmus</i>	21386	7612	Post
<i>Quercus</i>	10174	2173	Post
<i>Quercus</i>	21323	2173	Post
Salicaceae	11992	2178	Post (small)
Salicaceae	16758	2003	Post (small)
<i>Ulmus</i>	21320	7575	Post (small)
<i>Quercus</i>	10285	2032	Partition wall

Building 131 (North Area, North F)

	Unit	Feature	Description
<i>Ulmus</i>	23018	8354	Pillar
<i>Quercus</i>	22653	7958	Post
<i>Ulmus</i>	23047		Post
<i>Quercus</i>	22698	7972	Post
<i>Quercus</i>	23036		Post (small)
<i>Ulmus</i>	23035		Post (small)
<i>Quercus</i>	23025		Free-standing post, side room
<i>Quercus</i>	23026		Free-standing post, side room
<i>Quercus</i>	22692	7969	Ladder
<i>Quercus</i>	32312	7964	Ladder
<i>Quercus</i>	32309	7964	Ladder
<i>Ulmus</i>	23105	7990	Partition wall
<i>Ulmus</i>	23095	8369	Partition wall
<i>Ulmus</i>	23096	8369	Partition wall
<i>Ulmus</i>	21195		Construction wood/roof collapse

Building 77 (North Area, North G)

	Unit	Feature	Description
<i>Quercus</i>	17541	6050	Post
<i>Juniperus</i>	17544	6057	Post
<i>Quercus</i>	17537	6055	Post
<i>Quercus</i>	17540	6050	Post
<i>Quercus</i>	17538	6056	Post
Salicaceae	16495		Post (small)
<i>Quercus</i>	17543	6050	Partition wall
<i>Quercus</i>	16408		Construction wood/roof collapse
<i>Juniperus</i> , Salicaceae	16466		Construction wood/roof collapse
Salicaceae, <i>Quercus</i>	17519		Construction wood/roof collapse

<i>Quercus</i>	16497	3092	Construction wood/roof collapse
<i>Quercus</i>	17513	6054	Construction wood/roof collapse
<i>Juniperus</i>	16458		Construction wood/roof collapse
<i>Juniperus</i>	16466		Construction wood/roof collapse
<i>Quercus</i>	16479		Construction wood/roof collapse

Building 97 (South Area, South O)

	Unit	Feature	Description
<i>Juniperus</i>	19681	3527	Partition wall
<i>Juniperus</i>	19682	3527	Partition wall
<i>Ulmus</i>	19680	3527	Partition wall
<i>Ulmus</i>	19678	3527	Partition wall
<i>Ulmus</i>	19679	3527	Partition wall
<i>Ulmus</i>	19652	3527	Partition wall
<i>Juniperus</i>	18687	3527	Partition wall

Building 80 (South Area, South O)

<i>Quercus</i>	20082	3428	Pillar
<i>Juniperus</i>	18959	3431	Pillar
<i>Ulmus</i>	18960	3433	Pillar
<i>Juniperus</i>	18961	3433	Pillar
<i>Quercus</i>	18963	7413	Ladder
<i>Ulmus</i>	18935		Post/?ladder timber
<i>Juniperus</i>	22409	7414	Post (small), associated with ladder
<i>Ulmus</i>	18953	5041	Construction wood/roof collapse
<i>Juniperus</i>	18946		Construction wood/roof collapse
<i>Juniperus</i>	18942		Construction wood/roof collapse
<i>Juniperus</i>	18586		Construction wood/roof collapse
<i>Juniperus</i>	18943		Construction wood/roof collapse
<i>Juniperus</i>	18934		Construction wood/roof collapse
<i>Juniperus</i>	18948		Construction wood/roof collapse

<i>Juniperus</i>	18582	Construction wood/roof collapse
<i>Juniperus</i>	18586	Construction wood/roof collapse
<i>Juniperus</i>	18587	Construction wood/roof collapse
<i>Juniperus</i>	18591	Construction wood/roof collapse
<i>Juniperus</i>	18583	Construction wood/roof collapse
<i>Juniperus</i>	18948	Construction wood/roof collapse
<i>Juniperus</i>	18581	Construction wood/roof collapse
<i>Juniperus</i>	18502	Construction wood/roof collapse
<i>Juniperus</i>	18588	Construction wood/roof collapse
<i>Juniperus</i>	18590	Construction wood/roof collapse

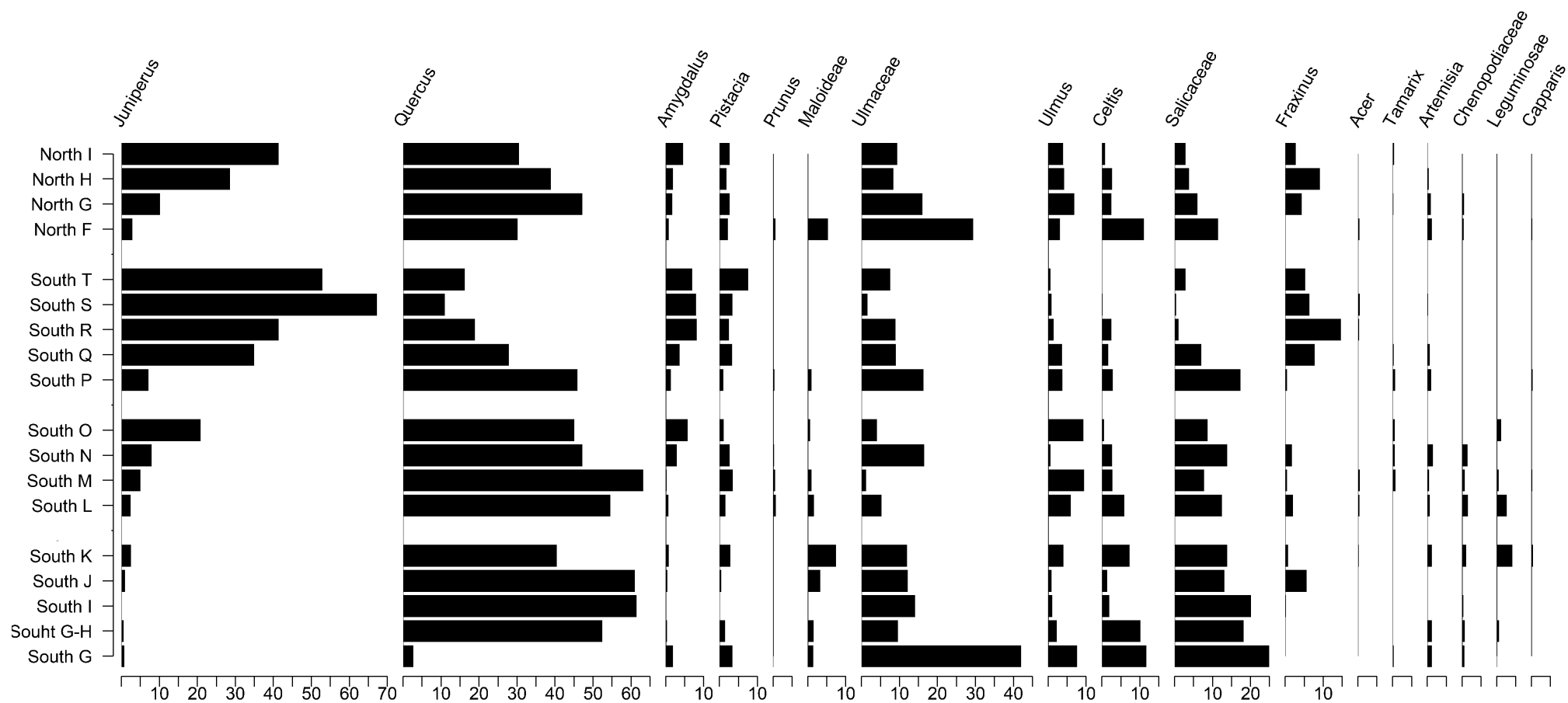


Fig. 4.1 Anthrachological diagram from all sampled phases at Çatalhöyük East (detailed dataset, cf. Table 4.1).

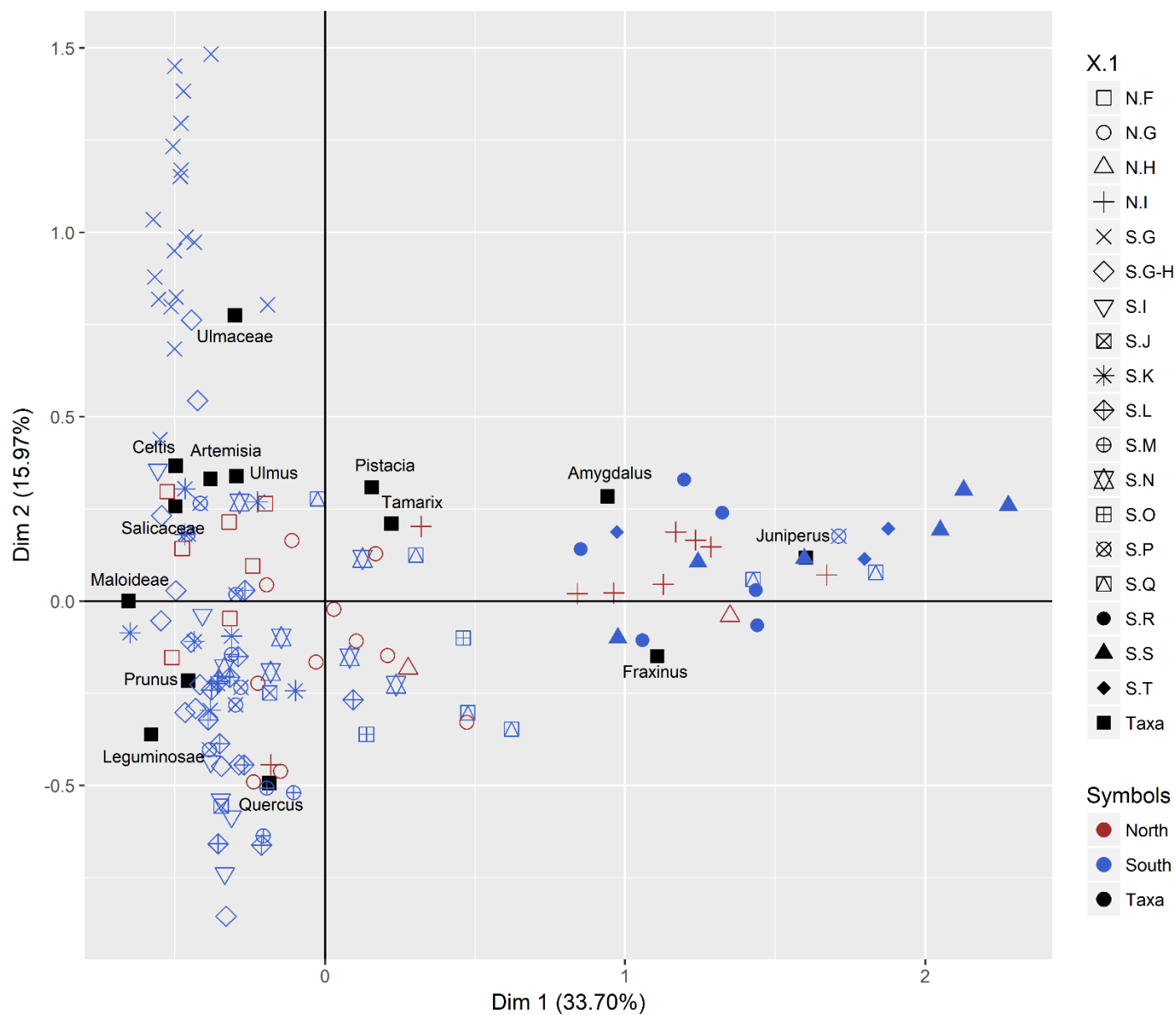


Fig. 4.2. Plot of Dimensions 1 and 2, CA run on per sample wood charcoal taxon counts from midden and midden-like contexts

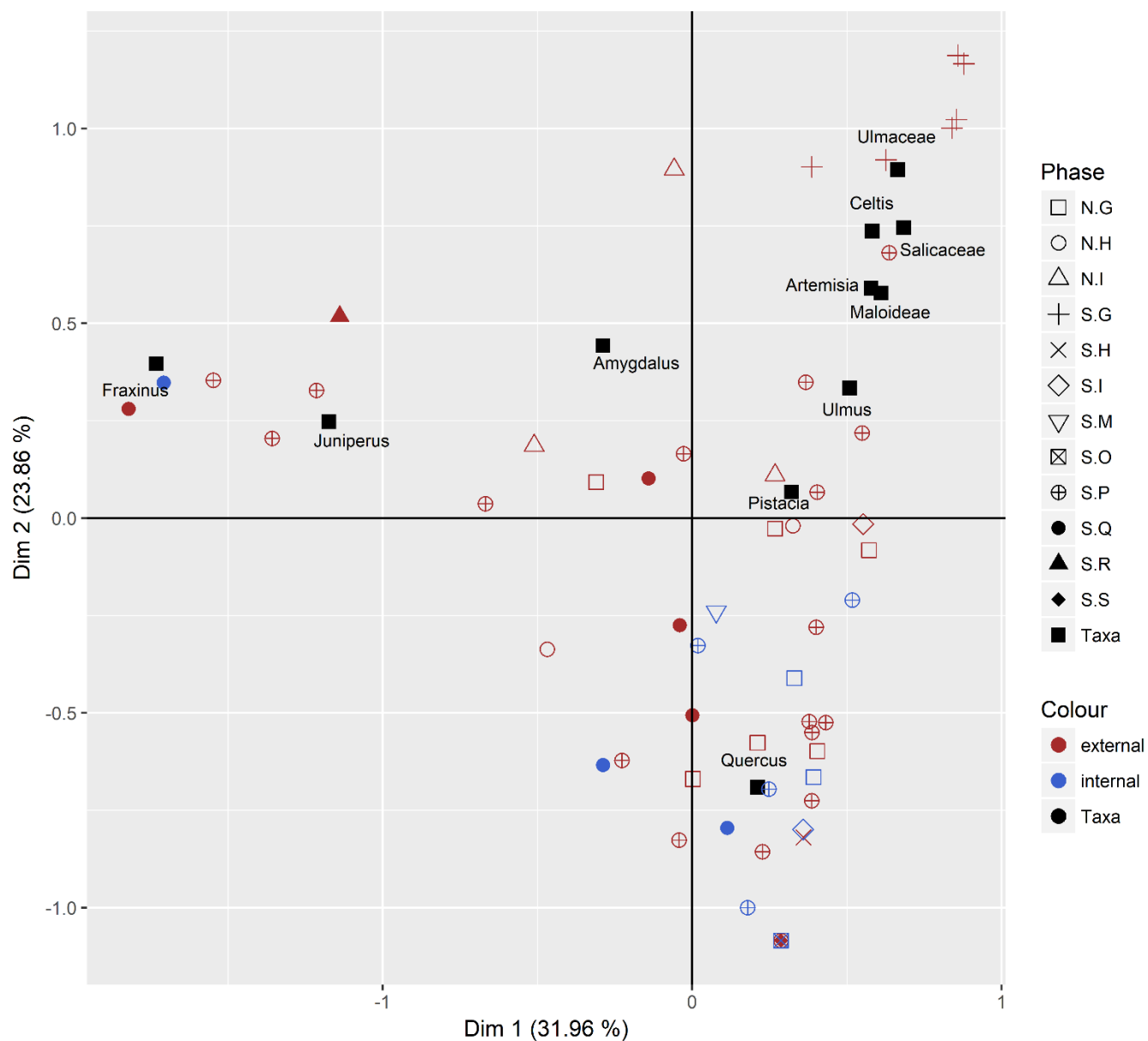


Fig. 4.3. Plot of Dimensions 1 and 2, CA run on per sample wood charcoal taxon counts from primary fuel waste deposits (internal and external)

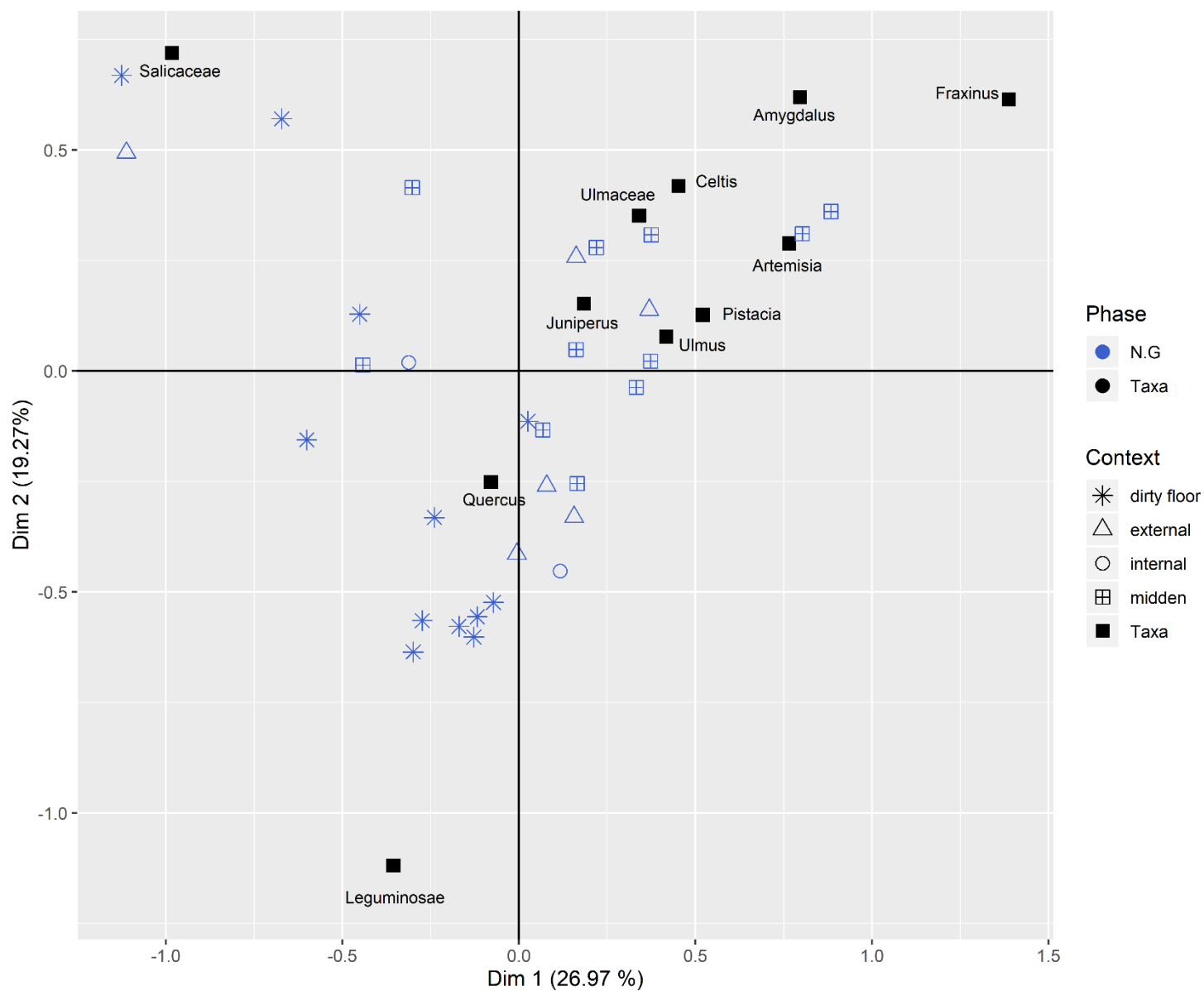


Fig. 4.4. Plot of Dimensions 1 and 2, CA run on per sample wood charcoal taxon counts from North G midden, fire feature and dirty floor deposits.

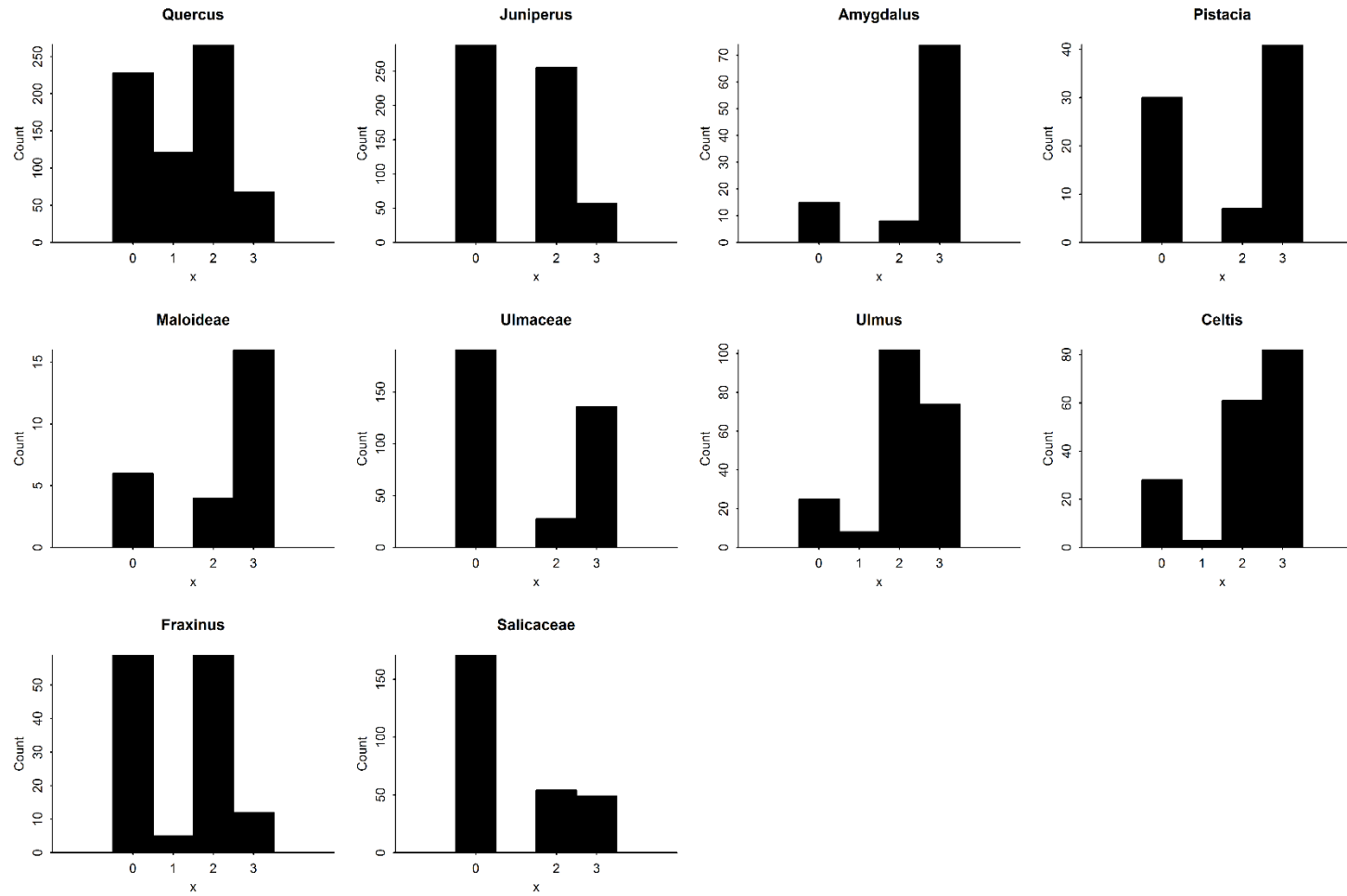


Fig. 4.5. Distribution of Curve Degree (CD) classes in midden contexts for different taxa at Çatalhöyük. CD 1= Weakly curved, CD 2= Moderately curved, CD 3= Strongly curved, 0= Indeterminate.

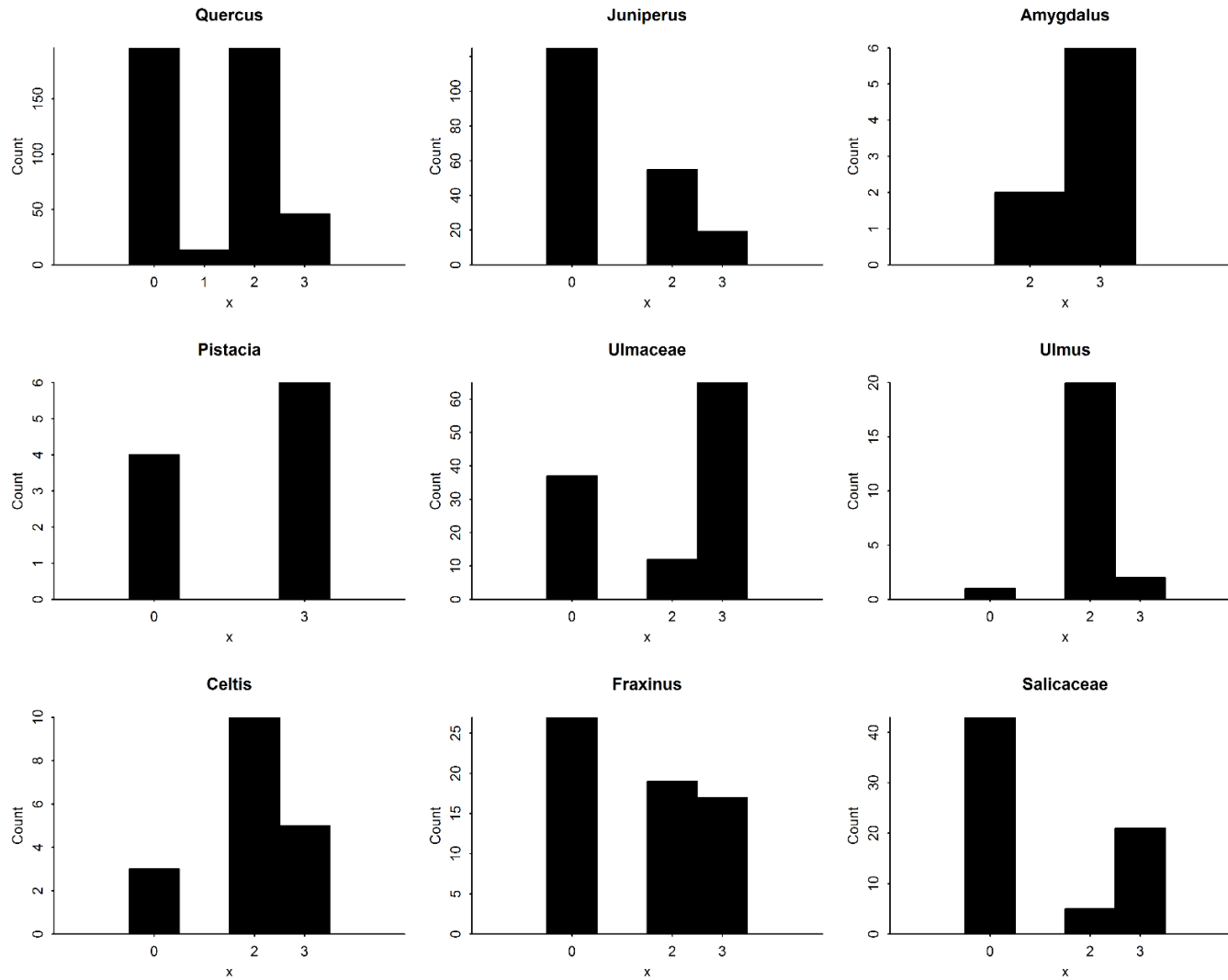


Fig. 4.6. Distribution of Curve Degree (CD) classes in fire features for different taxa at Çatalhöyük. CD 1= Weakly curved, CD 2= Moderately curved, CD 3= Strongly curved, 0= Indeterminate

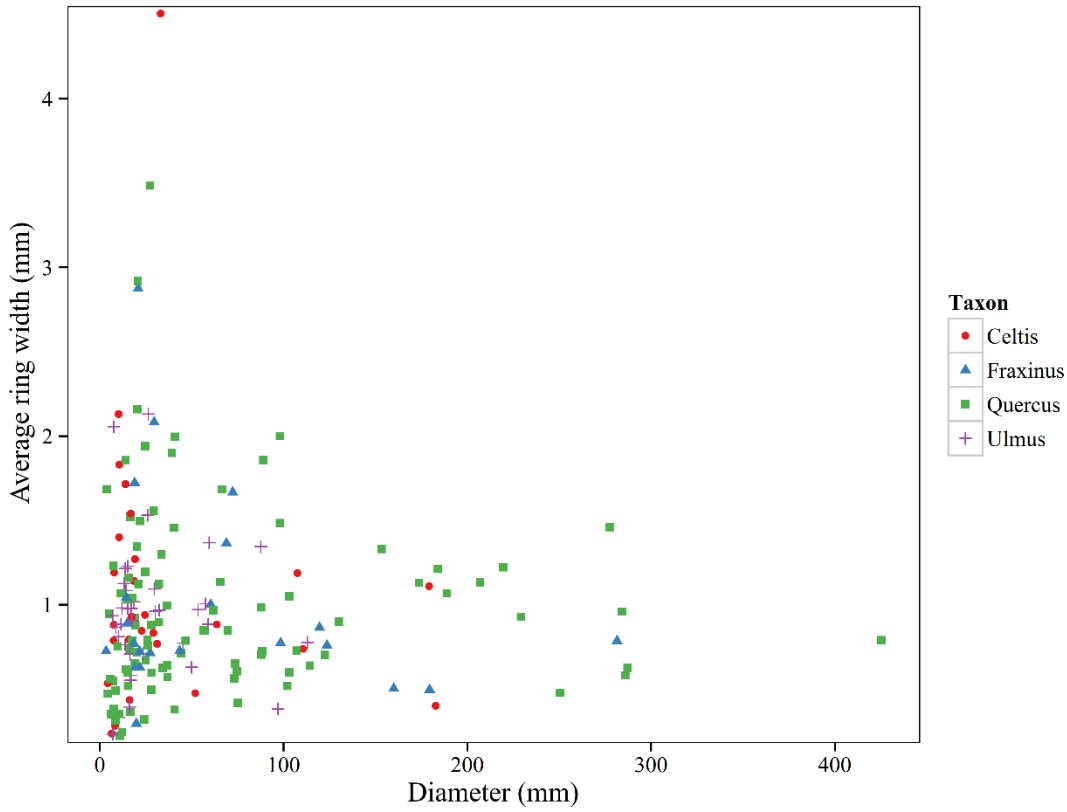


Fig. 4.7.a Scatter plot of average ring width and diameter measurements for each specimen from Çatalhöyük.

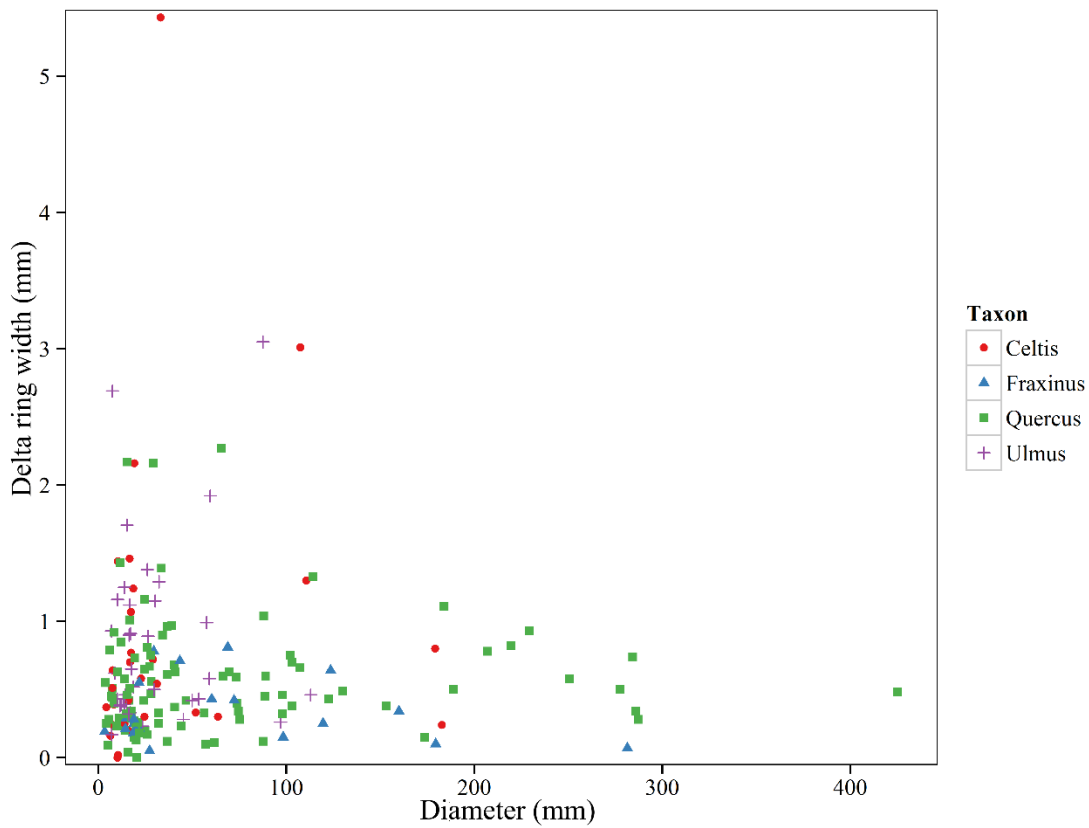


Fig 4.7.b Scatter plot of delta ring width (:maximum-minimum) and diameter measurements for each specimen from Çatalhöyük.

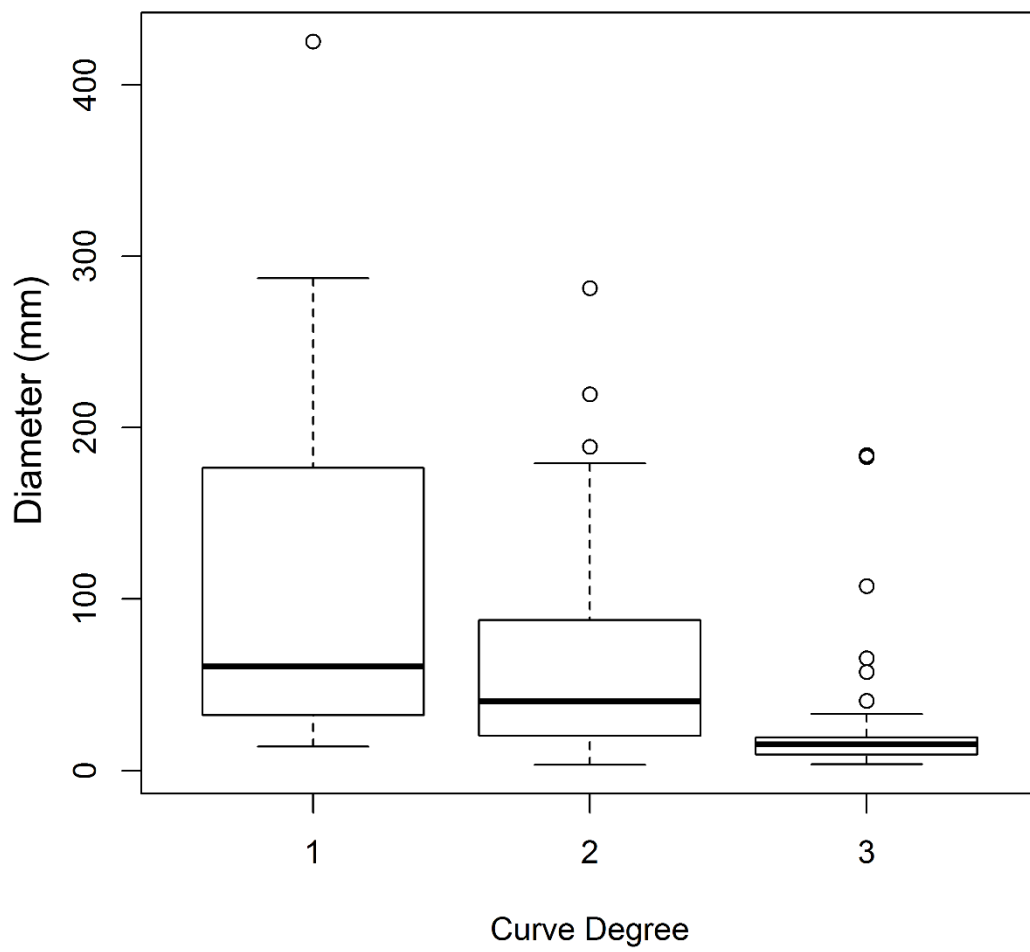


Fig. 4.8. Boxplots of diameter measurements for specimens of different Curve Degree classes

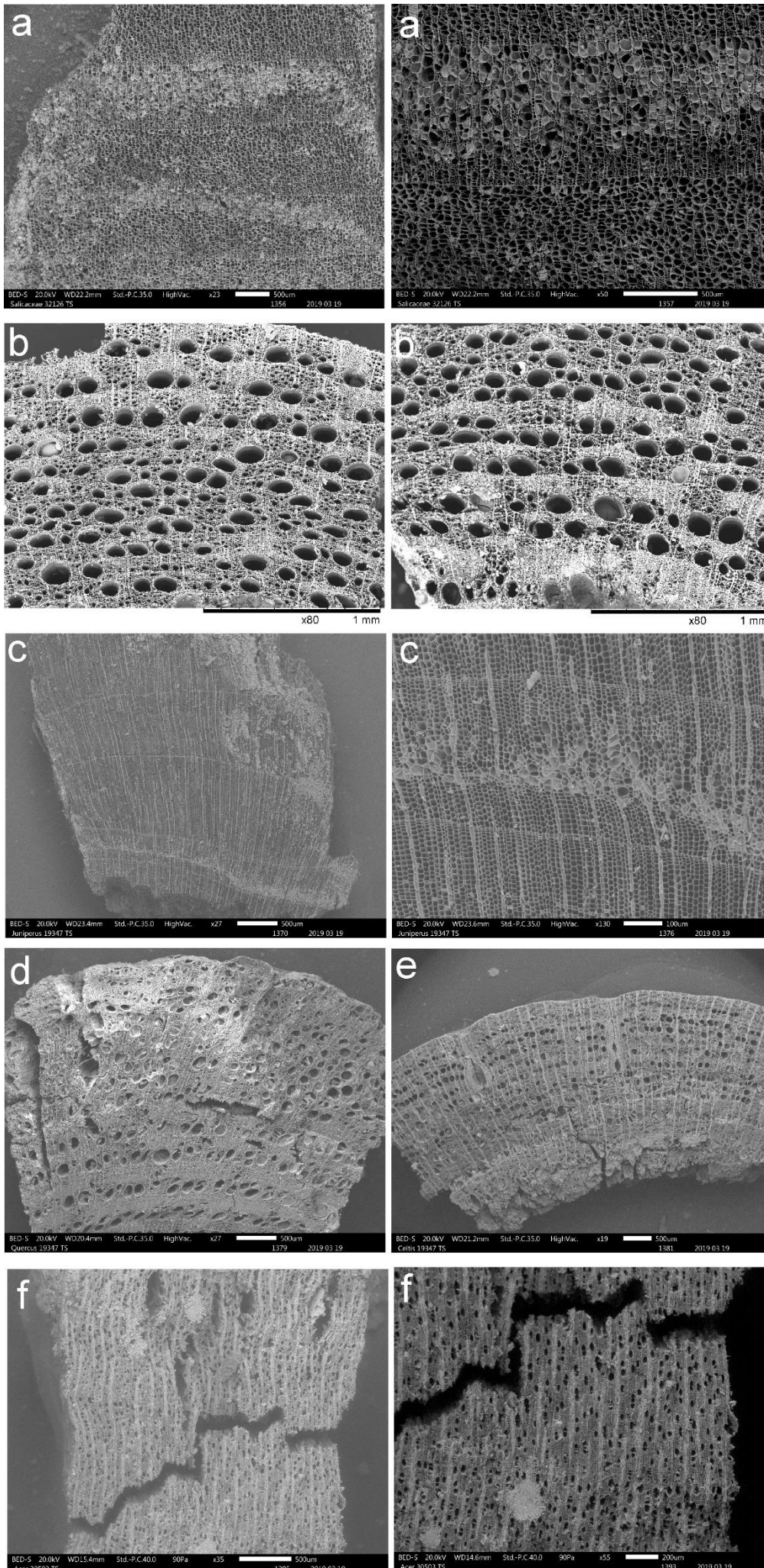


Fig. 4.9. Scanning Electron Microscopy on wood charcoal specimens from Catalhoyuk:

a) Traumatic tyloses in Salicaceae indicating fluctuations in the water table

b) Narrow and false/discontinuous growth rings in Quercus

c) Scar/callus tissue and traumatic resin canals associated with frost damage in Juniperus

d) Growth suppression in Quercus (associated with pollarding/defoliation)

e) Growth suppression in Celtis (associated with pollarding/defoliation)

f) Acer, fragment of wooden bowl (30503) (transverse sections)